PHYSICAL SCIENCES

The physical sciences encompass physics and astronomy, chemistry, and the earth and environmental sciences. These fields are more different than they are alike in where scientists are employed, the work they do, and the factors driving the demand for new researchers. Research physicists and astronomers depend primarily upon Federal research and development (R&D) support funneled into universities and national laboratories. In chemistry, basic university research is overshadowed by industrial R&D, which employs large numbers of R&D chemists at all degree levels, particularly Ph.D.s. Environmental sciences (comprised of earth, atmospheric, and ocean science specialties) is a small field, with a core of geologists dependent upon the economic health of the oil and mining industries and a collection of interdisciplinary researchers responding to environmental R&D priorities.

Generally, undergraduate degrees in the physical sciences have risen slowly but steadily since 1975. Graduate enrollments declined rapidly in the early 1970s, stabilized through the late 1970s and early 1980s, and have increased slightly but steadily since 1982. There is a risk of oversimplifying career patterns of physical scientists, yet there are two primary paths: physical scientists at the doctoral level are employed primarily in research and teaching, and baccalaureate and master% graduates are employed in a variety of jobs and fields. Young scientists respond both to the employment market of a field and the more volatile demand for particular specialties and skills. Growth in graduate enrollments and the number of Ph.D.s conferred, especially in physics, is due almost solely to increases in foreign students.

A continuing oversupply of physicists relative to physics research opportunities has made a Ph.D. and several years of postdoctoral experience necessary preparation for a research career. Students have continued to enter physics despite the dearth of research opportunities, perhaps because of the proven ability of bachelor’s and Ph.D. physicists to

move into other science and engineering fields. Astronomy is a small, university-based, basic research field, with near-total dependence on Federal support, but a theoretically challenging science that attracts many good students. In 1975, the astronomy community began discouraging entry of students into the field and diversifying graduate training to increase the job mobility of new astronomers.

Industrial and academic demand for research chemists has been relatively stable, with increasing emphasis on a graduate education for an industrial R&D position. The preferred entry level degree for earth scientists is the master%; there is smaller demand for basic researchers in this field. Many earth scientists are employed in the petroleum and mining industries, which are buffeted by business cycles and resource policies.

Physics and chemistry students prolong postdoctoral appointments during periods of sluggish demand. Unemployment is low among Ph.D. physical scientists, higher for recent bachelor% and master's graduates. Within each of these fields, however, shortages and surpluses occur for specific research specialties. Thus, there are current surpluses of new graduates in particle physics and petroleum geology, and at the same time shortages in optical physics and geochemistry. In some instances, there is a continuing mismatch between supply and demand, as in the continuing overproduction of particle physicists and theoretical physicists relative to research opportunities; other mismatches are transitory, such as the cyclical demand for geologists in oil industry exploration and R&D.

Women and non-Asian minorities are consistently underrepresented in the physical sciences. They receive only a small share of graduate degrees, particularly in physics, and an even smaller share of faculty positions.

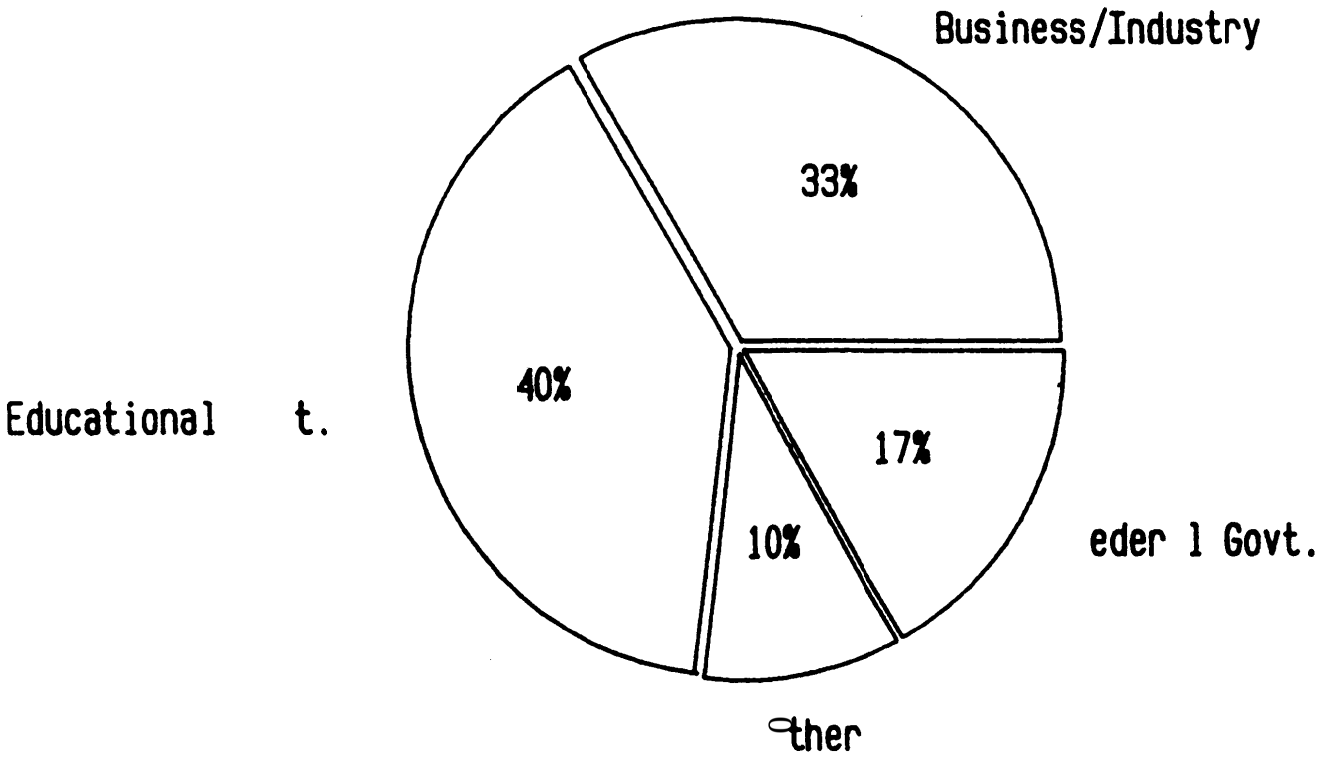
PHYSICS AND ASTRONOMY

Employment

- There are 40,000 to 70,000 employed physicists and astronomers in the United States.[1] The vast majority are employed in science and engineering (S/E) positions. These figures include astronomers, who represent about 10 percent of the total.
- Of physicists and astronomers working in S/E positions, most are employed by educational institutions, lesser proportions by industry and the Federal Government.[2]
- The primary work activity of physicists and astronomers employed in S/E is research and development; almost one-half of these are doing basic research. Another one-quarter are in various management positions and about 20 percent are engaged primarily in teaching.[3]
- There is a surplus of Ph.D. physicists relative to the number of physics research slots* This surplus is highly mobile and employable; more physics Ph.D.s are working in other fields than is true for any other science.
- of employed Ph.D. physicists, one-half work in academia. The rest are divided almost equally between industry and government (including national laboratories).[4]

1. Estimates of employed physicists and astronomers vary widely. For example, in 1985 the Bureau of Labor Statistics reported 40,000, which included 13,000 teachers. The National Science Foundation% preliminary 1986 estimate is 70,800. National Science Foundation, Science Resources Studies Division, preliminary 1986 estimates, Table B-1, unpublished data.
2. Ibid., Table B-13.
3. Ibid.
4. National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States: 1983, NSF 85-303 (Washington, DC: 1985), p. 19,–Table B-5.

Where Physicists* Work, 1986



*ALL DEGREES

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Education and Supply

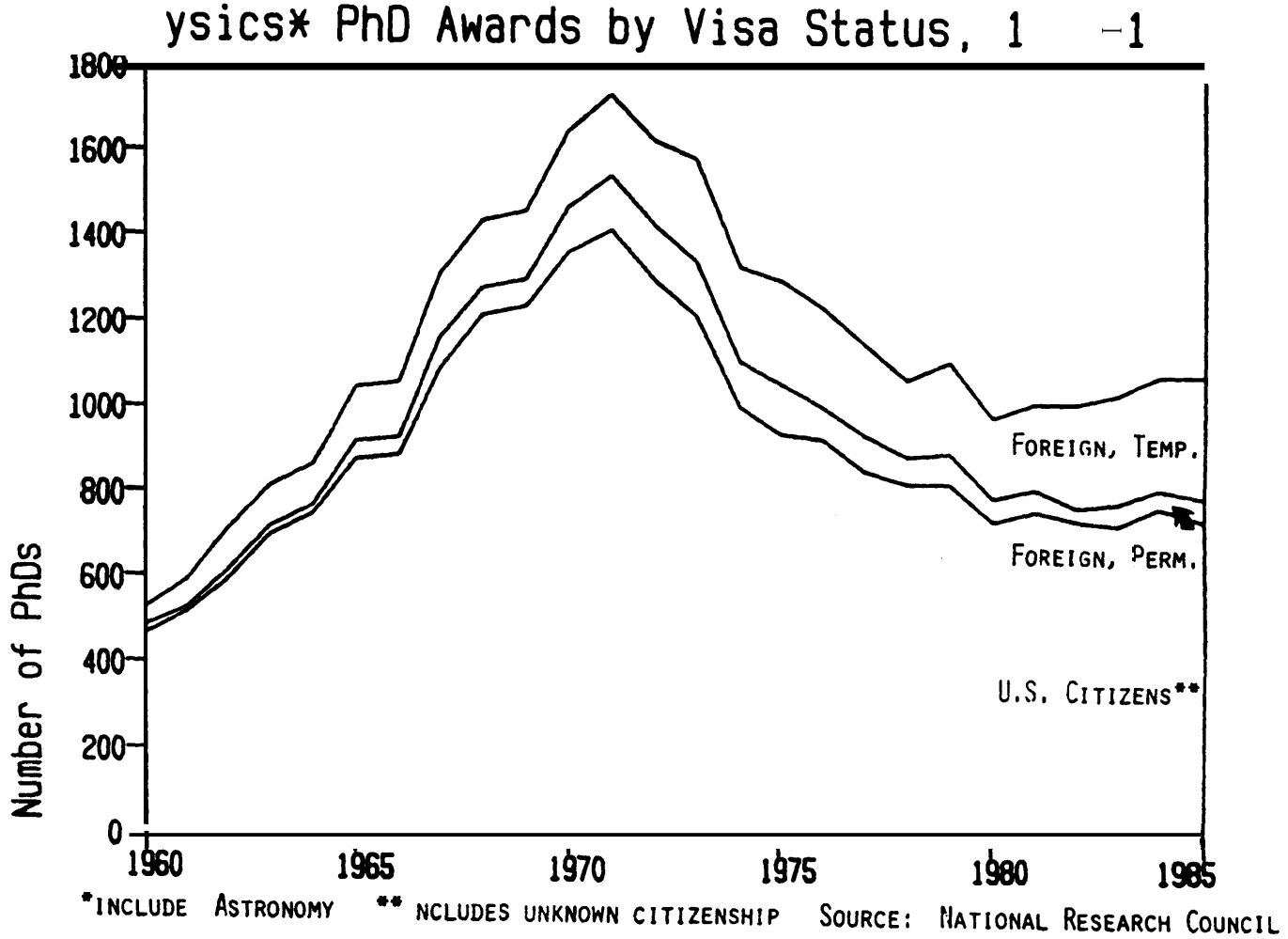
- The number of baccalaureate physics awards dropped rapidly through the 1970s, but has turned around and increased steadily since 1980. A smaller proportion are going on to graduate study; about one-half of baccalaureate physicists continue with some kind of graduate study, down from 60 percent 10 years ago. However, the decline is due to those changing fields; one-third of physics bachelors' continue with physics graduate study.[5]
- Graduate enrollments in physics have increased slowly and steadily in the 1980s. However, the increases are solely due to increases in foreign students; the number of U.S.-born physics graduate students has been stable since 1980.[6]
- Solid state, elementary particle, and nuclear physics are the leading specialties, but optics, medical physics, and plasma physics are expanding. Increasing attention to industry and government-related studies in graduate education has bolstered interdisciplinary study, particularly with engineering.
- Many physics graduate students take terminal master's degrees. Among those who earn a Ph.D., almost half accept postdoctoral appointments. This largely reflects the poor job market for physicists over the past decade.

Foreign Nationals, Women, and Minorities

- The presence of foreign nationals in physics has increased rapidly since the mid-1970s. Twenty-seven percent of physics Ph.D.s were awarded to foreign students on temporary visas in 1985, an additional 3 percent to those on permanent visas. Over one-third of currently enrolled physics graduate students are foreign nationals[7] Among the sciences, physics has a high proportion of foreign nationals

5. National Research Council, Physics Survey Committee, Physics Through the 1990s: An Overview (Washington, DC: National Academy Press, 1986), p. 110.

6. National Science Foundation, Academic Science/Engineering: Graduate Enrollment and Support, Fall 1983, NSF 85-300 (Washington, DC: 1985), pp. 104, 130-31, tables C-6, C-27, C-28, and unpublished NSF data on 1984 and 1985 enrollments.


ysics* PhD Awards by Visa Status, 1 -1
Number of PhDs
1800
1600
1400
1200
1000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
FOREIGN, TEMP.
FOREIGN, PERM.
U.S. CITIZENS**
*INCLUDE ASTRONOMY ** NCLUDES UNKNOWN CITIZENSHIP SOURCE: NATIONAL RESEARCH COUNCIL

among employed Ph.D.s — nearly 8 percent.[8]

- Women are still scarce in physics. Their participation is the lowest of all sciences, at all degree levels. Between 1980 and 1985, women received just over 7 percent of the physics Ph.D.s awarded.
- Blacks and Hispanics combined are 3 percent of employed Ph.D. physicists; Asians represent 9 percent. In the past 10 years, Asian-Americans have received seven times as many physics Ph.D.s as blacks and five times as many Hispanics. Although U.S. citizens, many of these Asian-Americans are foreign-born.

Astronomy

- There is a continuing oversupply of astronomers; research jobs are severely limited. Over half of Ph.D. astronomers work in Ph.D.-producing universities, many as non-faculty researchers and postdoctorates; many of the rest work in government.

7. Ibid.
8. National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States: 1983, op. cit., p. 12, Table B-3.

CHEMISTRY

Employment

- The chemistry work force is large and heavily industrial. Chemistry is second only to the biological sciences in number of researchers.
- There are between 129,000 and 195,000 chemists employed in the United States, most in S/E positions. Over two-thirds of S/E chemists are employed in industry, about 20 percent in academia and over 10 percent in Federal, State and local government.[9]
- Over one-third of the S/E employed chemists are engaged in R&D. Another 25 percent are in management positions and 14 percent in teaching.[10]
- The demand for chemists is driven in great part by industry. Industry conducts a significant amount of chemistry research; about 25 percent of the basic research community works in industry. The chemical industry employs the highest proportion of Ph.D.s of any industry.
- Of employed chemists, one-quarter hold the Ph.D. and the master's, respectively. The terminal degree of the rest is the bachelor%. There is no shortage of chemists. Chemistry is a flexible discipline; when one segrnent of the industry is in a downturn, chemists find related jobs. Chemists are relatively mobile; in 1983, 'one in three Ph.D. chemists were employed in other fields, compared to one in five computer science and two in five physics/astronomy Ph.D.s.[11]

9. In 1985, the Bureau of Labor Statistics reported 129,000 chemists, including 18,000 teachers. The Census Bureau estimated 110,620 chemists in 1980. The National Science Foundation% preliminary 1986 estimate is 195,200. National Science Foundation, Science Resources Studies Division, preliminary 1986 estimates, Table B-l, unpublished data.
10. Ibid., Table B-13.
11. National Research Council, Office of Scientific and Engineering Personnel, Science, Engineering and Humanities Doctorates in the United States: 1983 Profile (Washington, DC: National Academy Press, 1985), p. 18, Table 2-2.

- Technicians are particularly important to chemistry R&D and production, but little is known about them. Some have a bachelor% in chemistry and many enter the market with 2-year associate degrees. The chemical industry employs around 40,000 chemical technicians; perhaps another 20,000 are employed in other manufacturing industries. [12]

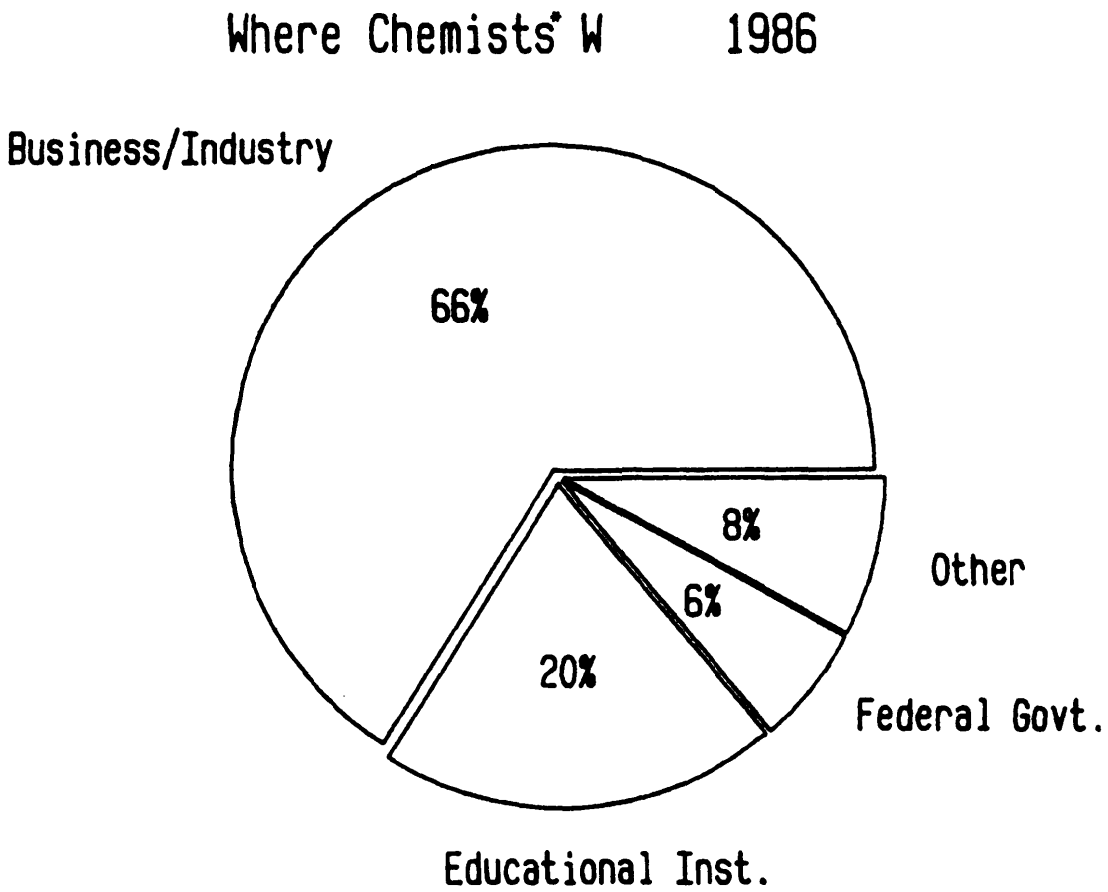
Education

- Increasingly, a Ph.D. is the accepted qualification not only for academic employment in chemistry, but for industrial employment as well. About 1,800 Ph.D.s are awarded annually in chemistry.
- About 11,000 students get a bachelor% degree in chemistry each year. Fewer than 2,000 of these students go on for a Ph.D.; another 1,000 get a master%. The average time to Ph.D. for 1984 chemistry Ph.D.s was slightly over 6 years since the bachelor%, the fastest of all fields.
- One or more years of postdoctoral research is accepted preparation for an academic research career. Almost one-half of new Ph.D.s goon to a postdoctoral appointment. [13]

Foreign Nationals

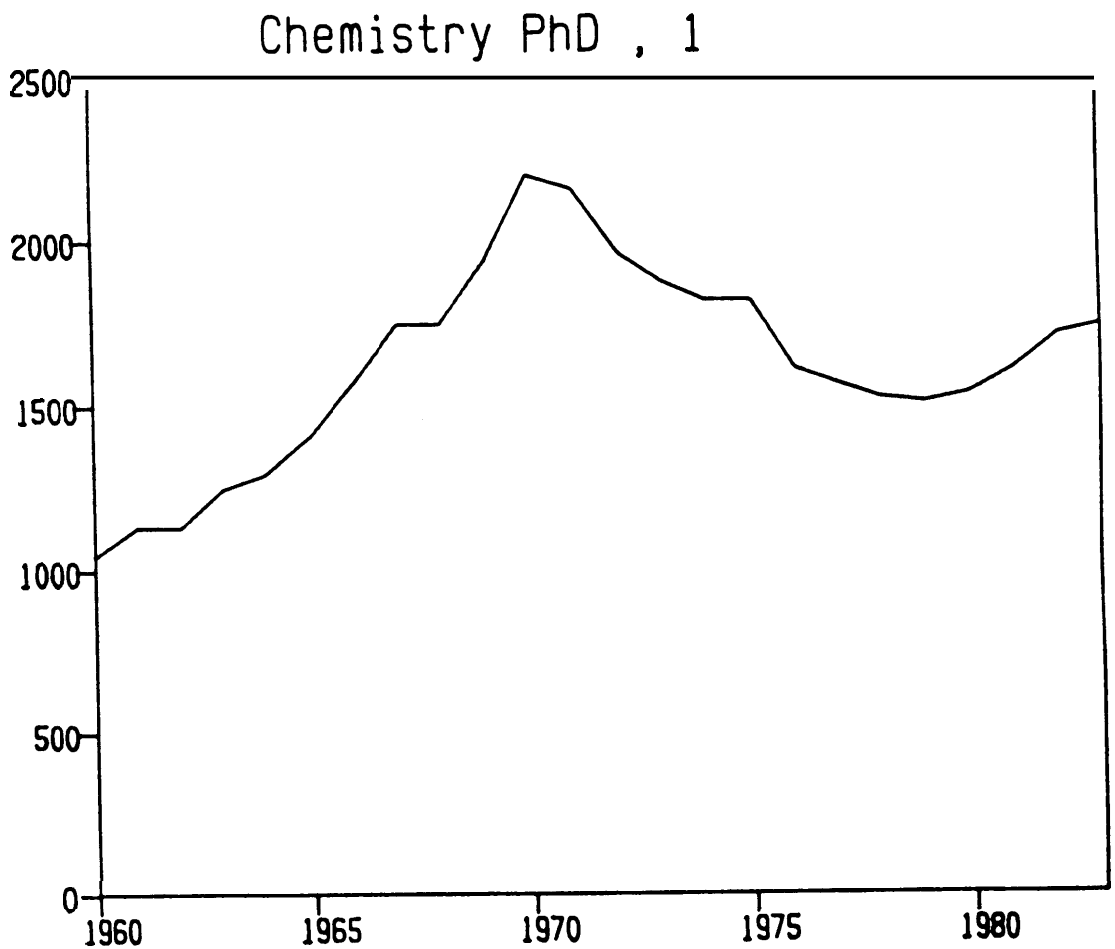
- The number of foreign graduate students in chemistry is rising slowly, although it is not as high as in physics and engineering. In 1985, nearly one in five of the Ph.D.s awarded went to foreign nationals on temporary visas; an additional 5 percent went to foreign nationals on permanent visas.

12. National Science Foundation, Scientists, Engineers, and Technicians in Manufacturing Industries: 1983, NSF 85-328 (Washington, DC: 1985), p. 23, Table D-2.
13. National Research Council, Office of Scientific and Engineering Personnel, Doctorate Recipients from United States Universities: Summary Report 1984 (Washington, DC: National Academy Press, 1986), p.34, Table 2.



*ALL DEGREES

SOURCE: NATIONAL SCIENCE FOUNDATION



SOURCE: NATIONAL RESEARCH COUNCIL

- More foreign students are staying in the United States after receiving their doctorate. Three in five on temporary visas enter postdoctoral research, with only 5 percent going directly into industry.

Women and Minorities

- Women have made slow but steady progress in chemistry at all degree levels. The proportion of chemistry Ph.D.s earned by women has doubled in 10 years, from 10 percent in 1975 to nearly 20 percent in 1985.
- Women are 13 percent of employed chemists (up from 6 percent a decade ago), but over one-quarter of unemployed chemists seeking work. Women chemists in academia are more likely to be in junior positions, untenured, and more than twice as likely to be working part time.
- Blacks and Hispanics have made no gains in chemistry in the past IO years. Blacks receive fewer than 2 percent of chemistry Ph.D.s, and barely more than 2 percent of bachelor's degrees. In comparison, Asian-Americans earned 6 percent of the chemistry Ph.D.s in 1985, up from 1 percent in 1975.